

Adapting to Climate Change in Canadian Agriculture

A Policy Issue Paper Prepared for the
Agriculture and Agrifood Climate Change
Table

Allen Tyrchniewicz

February, 1999

The International Institute for Sustainable Development (IISD) is an independent, not-for-profit corporation headquartered in Winnipeg, Canada, established and supported by the governments of Canada and Manitoba. Its mandate is to promote sustainable development in decision-making in Canada and around the world.

Copyright © 1999 International Institute for Sustainable Development

Published by the International Institute for Sustainable Development

All rights reserved

Printed in Canada

Copies are available from IISD. Copies may also be ordered through IISD's online order form at <http://iisd.ca/about/prodcat/ordering.htm>

This publication is printed on recycled paper.

International Institute for Sustainable Development
161 Portage Avenue East, 6th Floor
Winnipeg, Manitoba
Canada
R3B 0Y4

"Adapting to Climate Change in Canadian Agriculture" was commissioned by the Agriculture and Agrifood Climate Change Table

TABLE OF CONTENTS

TABLE OF CONTENTS	3
BACKGROUND	1
CLIMATE CHANGE PREDICTIONS	2
POLICY IMPLICATIONS OF CLIMATE CHANGE	12
WHY ADAPT	12
WHAT DO WE NEED TO KNOW	13
WHAT DO WE KNOW	14
WHAT ARE THE GAPS	15

Background

Climate change could prove to be one of the most significant challenges facing the world. While the potential impacts in economic, environment and social terms have yet to be fully understood, globally there might not be the time to wait. When the International Panel on Climate Change announced in 1995 that "there is discernible human influence on global climate", the world took notice.

160 countries negotiated the Kyoto Protocol to address the emissions of greenhouse gases to reduce the impacts of climate change. (IISD, 1998) The Kyoto Protocol becomes a legally binding agreement when 55% of Annex 1 countries responsible for 55% of greenhouse gas (GHG) emissions ratify the Protocol. Canada has signed the Kyoto Protocol, but still needs to ratify it. Canada has committed to reducing its GHG emissions by 6% from its 1990 levels. Based on the increased emissions since 1990 levels, Canada needs to reduce its emissions by approximately 25%. Canada's agricultural and agri-food sector will be expected to reduce its GHG emissions to assist Canada in meeting the commitments to the Kyoto Protocol.

There are two overall approaches, or strategies, for responding to predicted climate change: mitigation and adaptation. *Mitigation* attempts to address the causes of climate change and can be classified into three broad areas: reducing sources of GHGs; maintaining existing sinks of GHGs; and expanding sinks of GHGs. *Adaptation* is concerned with responses to the effects of climate change. It refers to any adjustments that can be undertaken to ameliorate the expected or actual adverse effects of climate change (Adger et al, 1997).

While it is important to reduce emissions of GHG's, it is also necessary for society to adapt to the changing climate. Agriculture is highly dependent on climate to produce food and fibre. A change in the temperature, precipitation and other climatic variables will have a significant impact on agricultural production. This in turn has an impact on the ability of farmers to produce food, fibre and an income. Addressing climate change requires two types of adaptation:

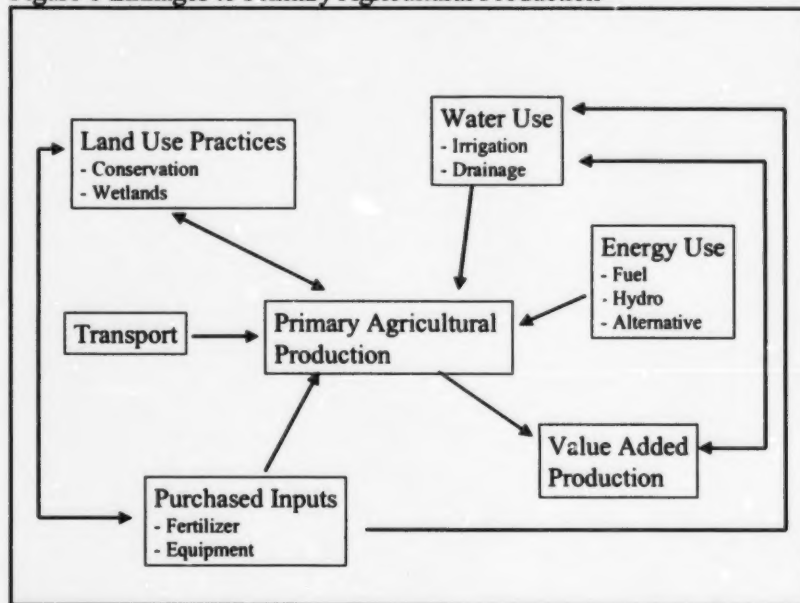
***Autonomous (or implicit):** this is an on-going process where individuals and organizations respond to climate variability and climate change without explicit policy intervention.*

***Policy-driven (or explicit):** the range of adaptation policies is potentially quite broad and includes specific adaptation technologies, as well as institutions and regulatory frameworks. It is possible to also include policies that enable autonomous adaptation to occur in the future. (MacIver, 1998)*

Government policies have had a significant impact on agriculture and will continue to do so as governments react to climate change (Tyrchniewicz and Wilson, 1994). Agriculture will not only have to adapt to the physical aspects of climate change, but also the policy changes related to climate change in agriculture and sectors associated with agriculture. Figure 1 outlines some of the linkages between primary agriculture and other sectors.

Linkages between agriculture and such things as water use, energy use, transportation and value added production, makes agriculture susceptible to changes not directly associated with agricultural production. Water-use will become a critical issue in most agricultural areas of Canada, because of the potential for less water and the increased competition for the available water from processing and communities, as well as habitat. Energy policies could prove to have a large impact on agriculture depending how governments choose to mitigate greenhouse gases, because most agricultural production processes are highly dependent on fossil fuels. Transportation policies have an impact on the ability to move farm products from the farm gate to the market, as well as the movement of inputs to the farm. Other inputs can also be affected by changes in policies not geared for agriculture. To successfully adapt to climate change, these are just some of the things that need to be considered.

Figure 1 Linkages to Primary Agricultural Production



Climate Change Predictions

Climate change will modify agricultural growing conditions around the world. On a global basis, it is not clear whether food production will increase or decrease because of climate change. Regional impacts however, are likely to be substantial and variable, with some regions benefiting from a climate change and other regions adversely affected. Generally, food and fibre production is likely to decline in most critical regions (e.g. subtropical and tropical areas), whereas agriculture in developed countries may actually benefit where technology is more available and if appropriate adaptive adjustments are employed. (Tychniewicz and Choitti, 1997) To adapt to the physical aspects of climate change, scenarios are required to predict some of the consequences of climate change that go beyond the global predictions.

General circulation models (GCMs) are tools used to generate climate change scenarios. These models utilize the physical laws of conservation, mass, moisture and energy to create a detailed three dimensional model of the climate system. (Tyrchniewicz and Choitti, 1997) The three most commonly used scenarios resulting from GCMs are Environment Canada's second generation CCC GCMII, Princeton University's Geophysical Fluid Dynamics Laboratory (GFDL) GCM, and NASA's Goddard Institute for Space Studies (GISS) GCM (Taylor, 1996). The GCMs indicate the agricultural regions in Canada could receive warming temperatures. Most of the GCMs are not clear on precipitation, but all suggest changing precipitation pattern for the agriculture regions. The models also suggest an increase in extreme weather events, such as thunderstorms and hailstorms, in most regions.

The following maps are based on Environment Canada's CCC GCMII model. They indicate how the temperature and precipitation are predicted to change across Canada. The maps are broken down into spring, summer, fall and winter.

Figure 2 Spring Temperature Changes

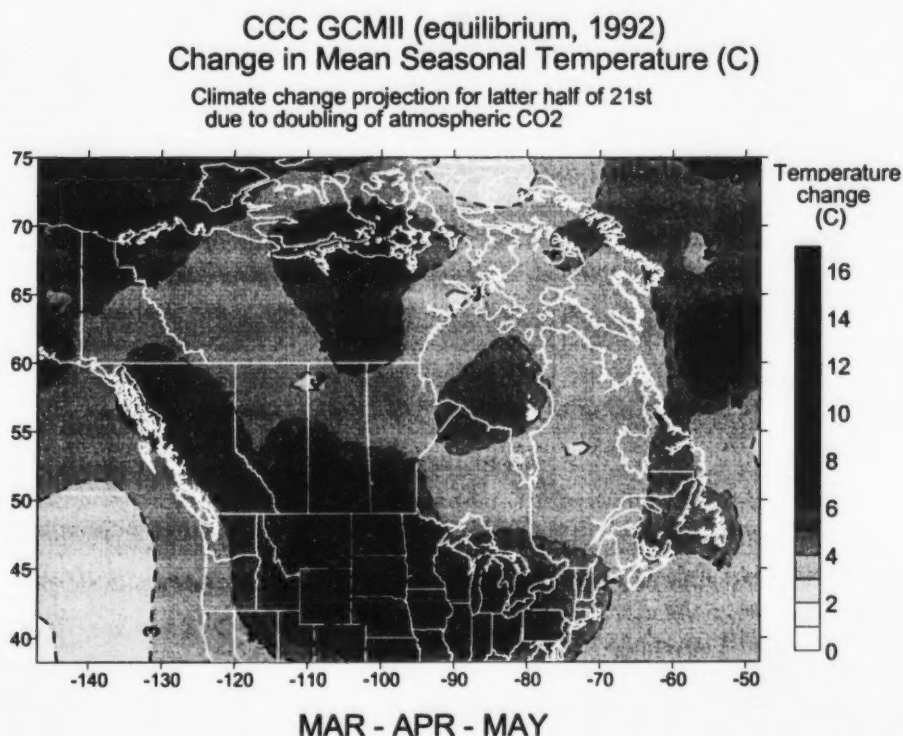


Figure 3 Spring Precipitation Changes

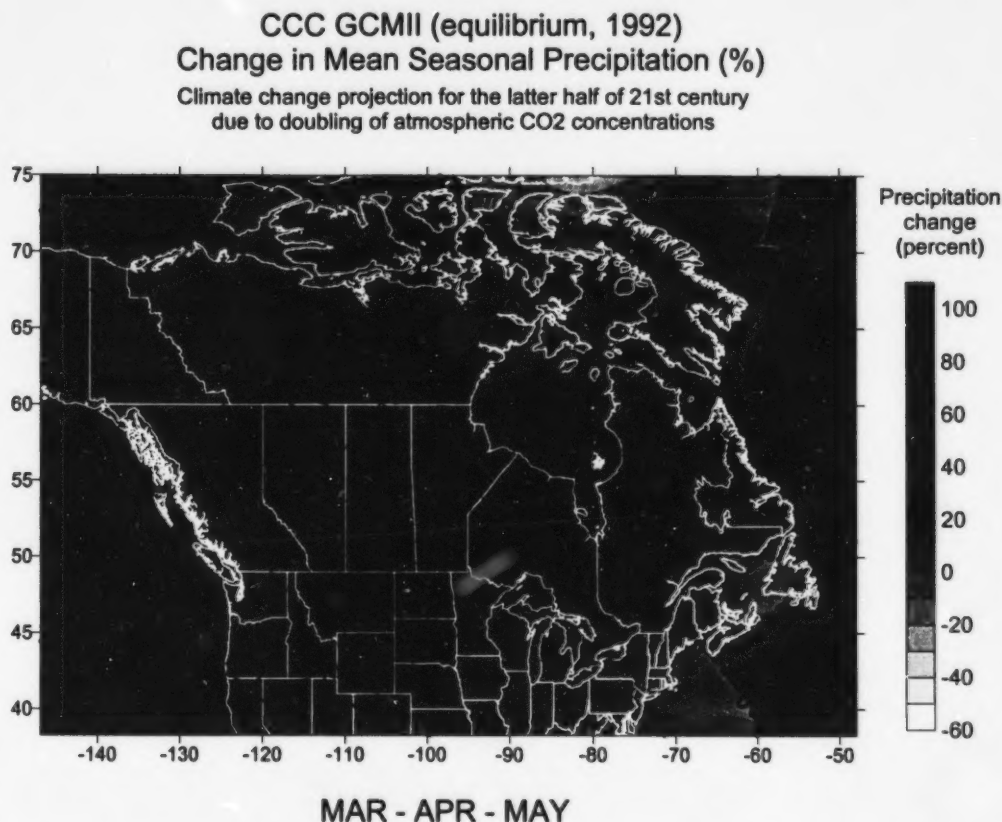


Figure 2 indicates above normal spring temperature increases. The prairies and southern Ontario appear to be the most affected by the changing climate in the spring. This increase is predicted to lead to earlier seeding times of most crops. As indicated in Figure 3, precipitation across Canada increases, with a significant percentage change in the Prairies ranging from 20 to 50 percent. This could prove to be useful by increasing the moisture of the seedbed, but it will depend on timing and temperature. With the increase in temperature and precipitation in the spring, some areas of the Prairies could experience increased flooding.

The coastlines do not appear to experience significant changes from the spring model, as temperature increases are modest and precipitation does not appear to change. It should be pointed out however, associated with climate change is an increase in sea level, which will have a significant impact in the form of flooding in some areas.

The agriculture regions of Ontario and Quebec will experience temperature increases, and have a slight increase in precipitation, which could increase the potential for flooding in these areas as well.

In all regions, the increased temperature should lengthen the growing season by enlarging the potential for frost-free days. This could also lead to an early emergence of pastures, reducing some input costs for some livestock.

Figure 4 Summer Temperature

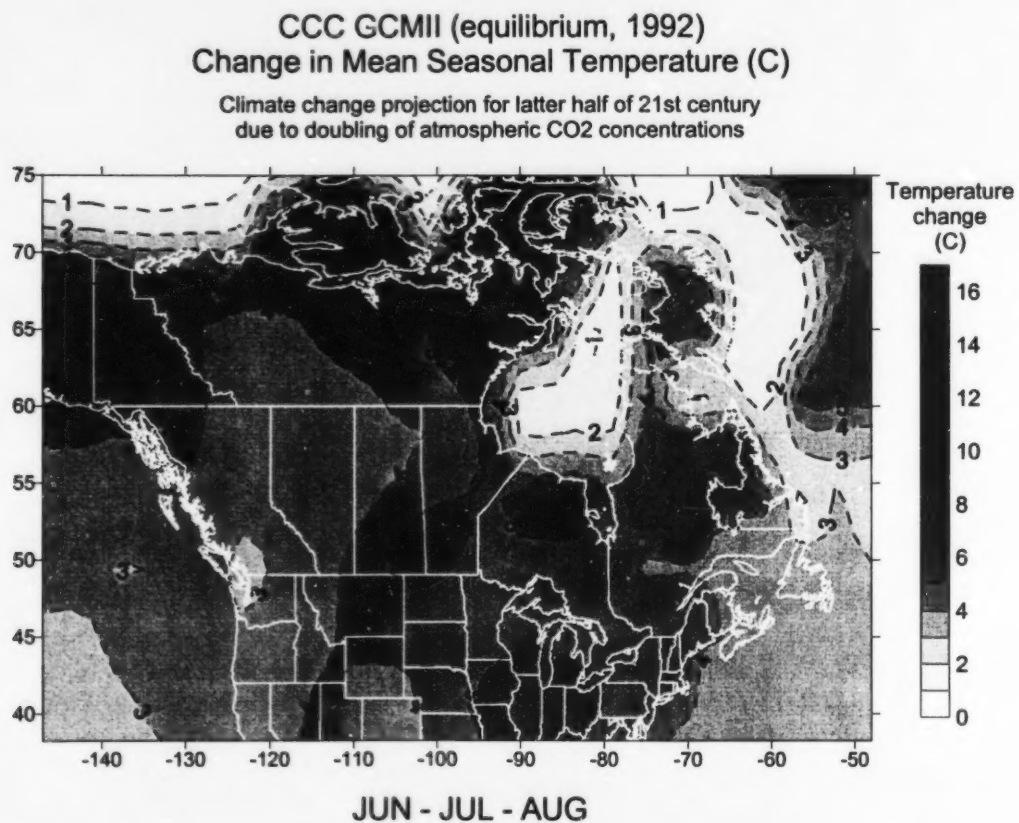
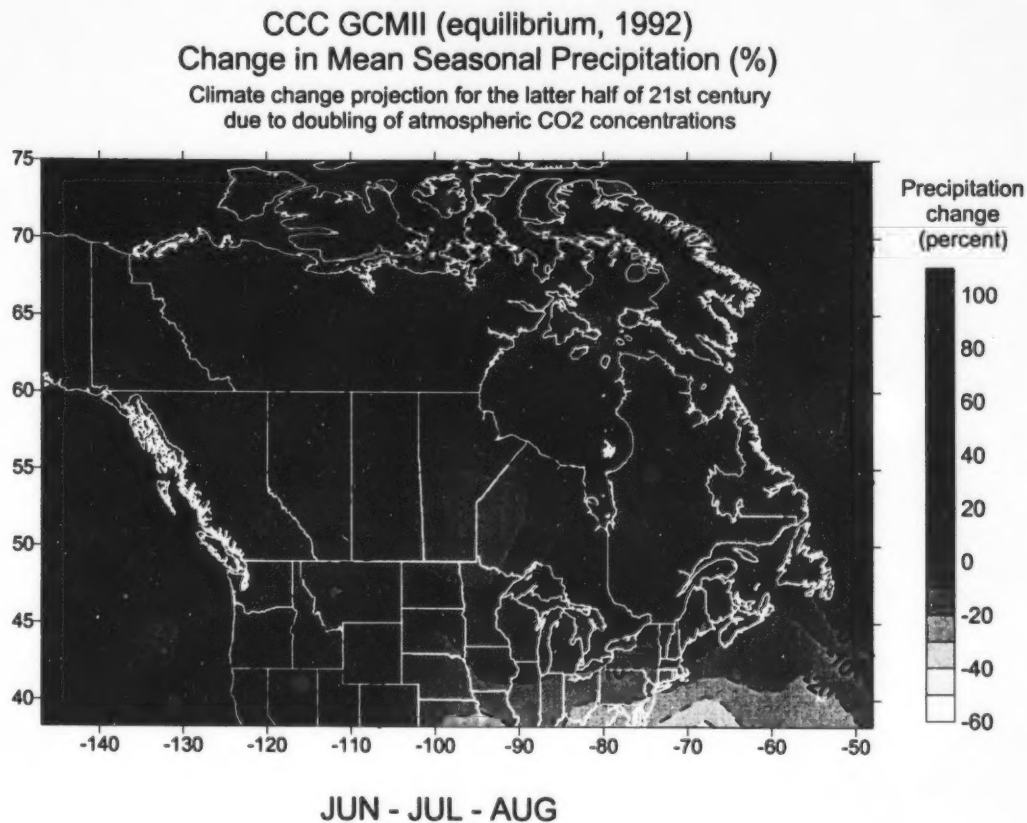


Figure 5 Summer Precipitation Changes



As indicated in Figure 4, summer temperature increases seem to range from 3 to 5 degrees Celsius above normal. This has the potential to increase evaporation across all of Canada, reducing the amount of available water. Water management will be a critical issue for all parts of Canada. Figure 5, summer precipitation changes, emphasizes this point further, by indicating a reduction in precipitation in most of Canada's agricultural regions ranging between 0 and -10 percent with extreme changes occurring in the eastern part of the Prairies ranging from 10 to 20 percent less precipitation. There is also a potential for increased heat stress on livestock due to climate change. The additional heat units, however, could increase the variety of crops available to the farmer.

Figure 6 Fall Temperature Changes

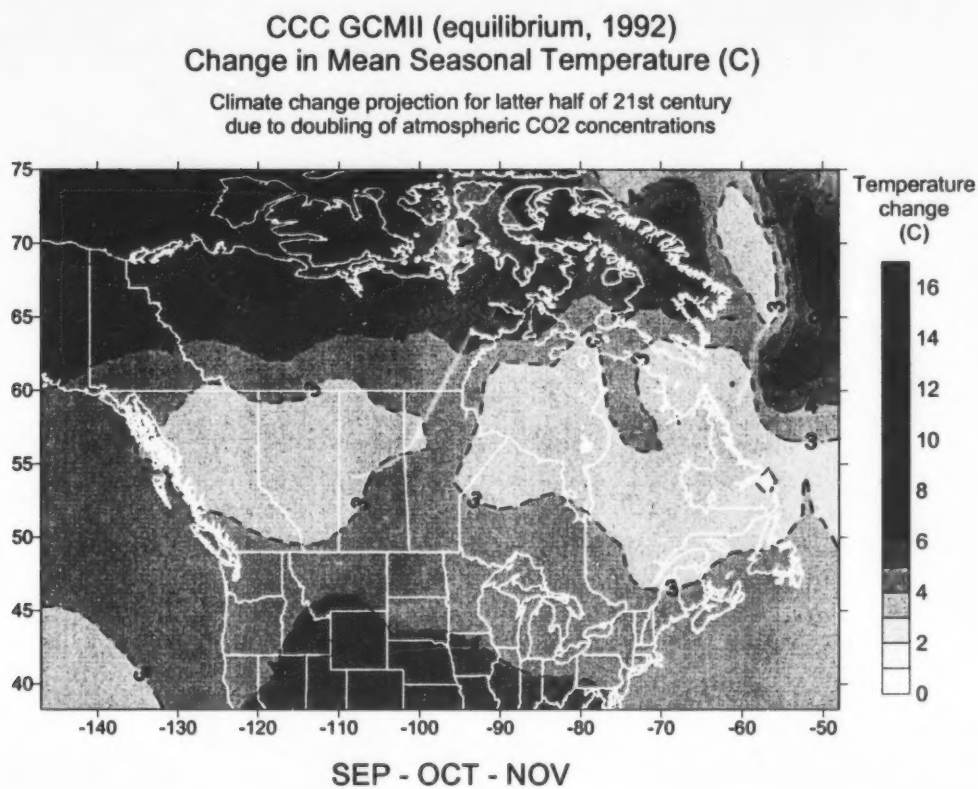
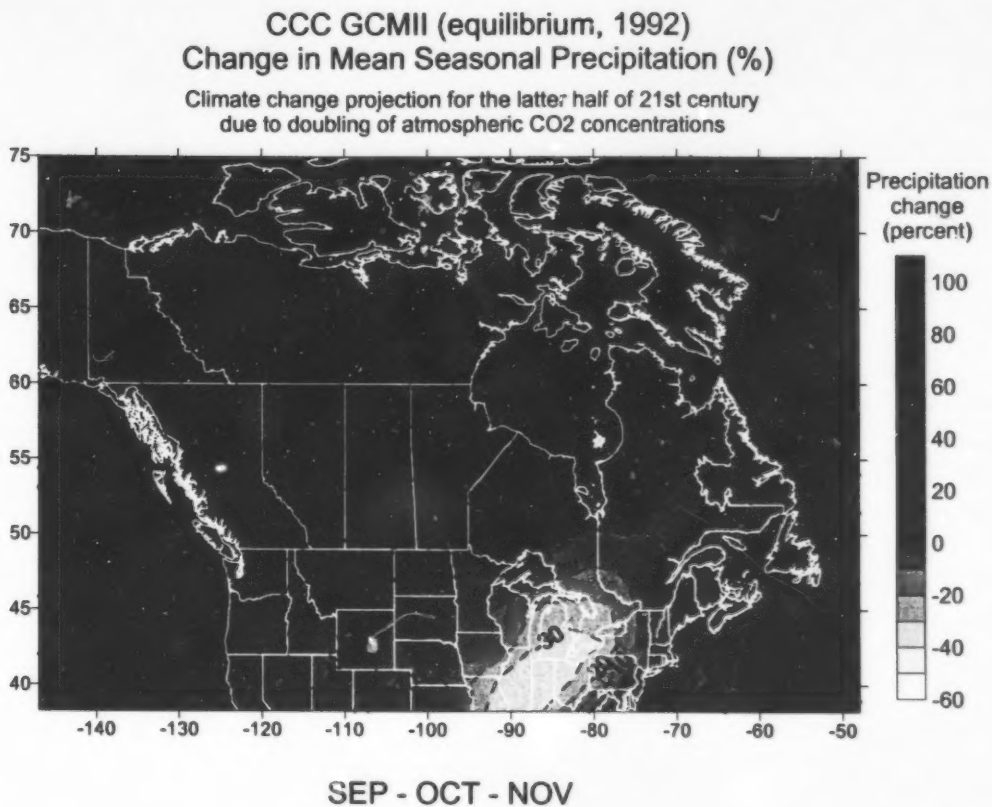


Figure 7 Fall Precipitation Changes



The increases in fall temperatures appear to be consistent across Canada, as shown in Figure 6, ranging from 3 to 4 degrees Celsius. Fall precipitation is varied across Canada, with increases in the northern regions and decreases in the south. Southern British Columbia has a potential increase of 20 percent. The temperature impact of this could be an increase in frost-free days.

The decreasing precipitation in Southern Ontario could prove to be harmful by not recharging the soil moisture.

Figure 8 Winter Temperature Changes

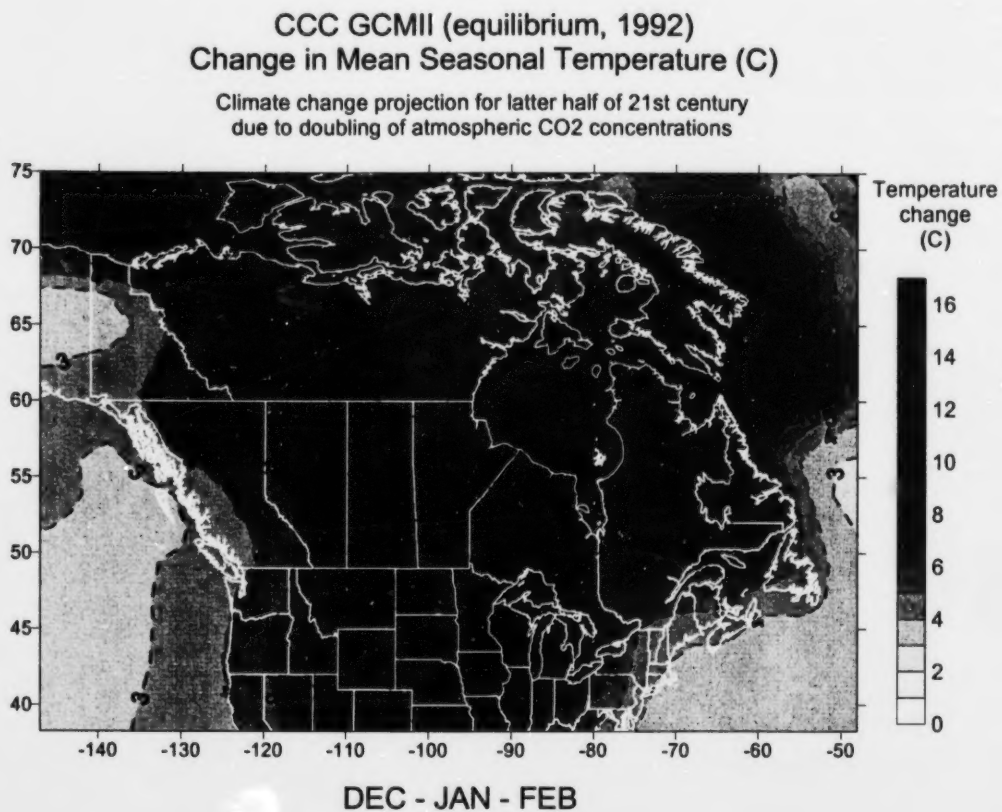
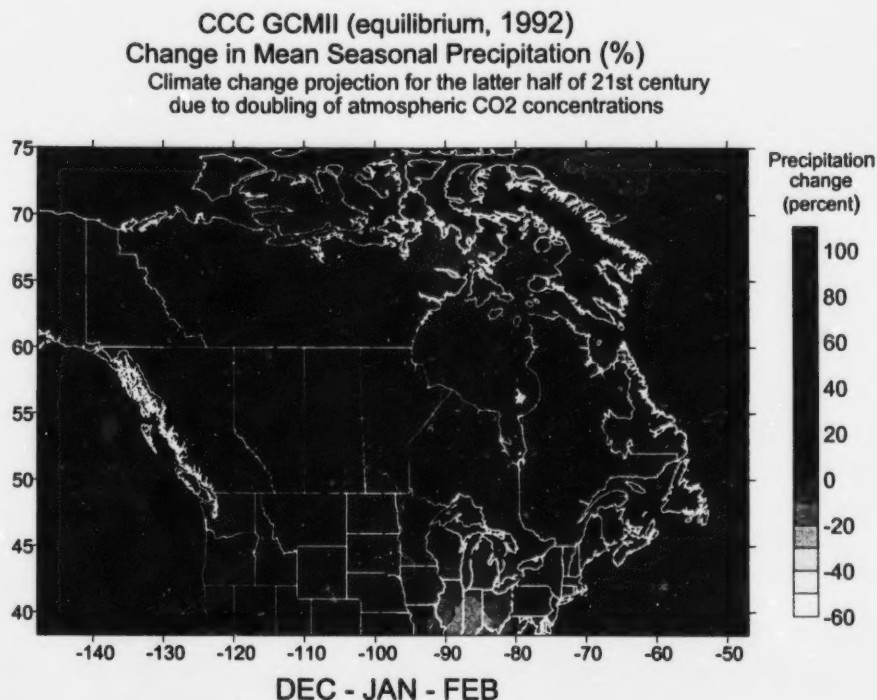


Figure 9 Winter Precipitation Changes



Figures 8 and 9 outline the temperature and precipitation changes expected for winter. With an increase between 3 and 11 degrees Celsius during the winter, this could have significant impacts in both crop production and livestock. The warmer temperatures in much of the livestock areas of Canada have the potential to reduce the cold stress, as well as improve feed efficiencies. Crop production may be impacted by the increase temperatures through the ability of some pests being able to survive the winter, when in the past many pests were killed off by cold temperatures. This could be difficult to assess, as the increased temperatures would improve survivability, while the reduction in snow cover could decrease survivability.

Agricultural production in the growing regions in the eastern Prairies and southern Ontario could be hindered by the reduction in precipitation, as moisture would not be able to recharge the soil. Again, this is also difficult to assess as a reduced snow cover could reduce the potential for soil erosion in the spring run-off, but the reduced snow cover on the land could increase the potential for wind erosion.

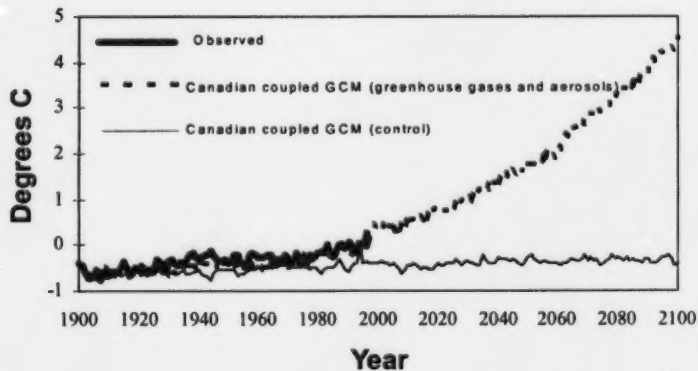
The changing winter climate could offer an interesting opportunity for moving more products through the Port of Churchill. Hudson Bay will be ice-free for a longer period of time, although, it should be noted that the rail line to Churchill might experience difficulties, as the permafrost would not be as stable and the tracks would shift. This is just one example of how

grain-handling activities could be affected by climate change.

Although the predictions of the CCC GCMII model on temperature and precipitation are not for certain, it should be noted that the other GCM models, GFDL and GISS are very similar in their predictions and close to actual observations. Figure 10 outlines the current trends between predicted, actual and the status quo for temperature. These models are predicting for the later half of the 21st century, so the changes outlined are not expected for 50 years or so, as well, the models indicate climate not weather. Actual weather observations can vary from year to year with magnitudes higher or lower than the predicted values.

Figure 10 Observed and Modeled Global Temperature Change

1: PREDICTED TEMPERATURES



Source: Jim Bruce, 1998 Presentation to the Agriculture and Agri-Food Issues Table

While the models predict the results expected when the carbon dioxide doubles in the atmosphere, the variability of the climate and the local rate of change could be dramatically different from the global average (Schimmelpfennig et. al.). A change in the normal path of storms could have an impact on the amount of rain a particular area received, either reducing it or increasing it. On top of this, agriculture could be facing heavier rains and higher winds because of an increased intensity of storms resulting in wind damage and soil erosion.

Policy Implications of climate Change

Assessing the climate change implications for agricultural policy is difficult due to the complex interactions between land use practices and the changes in greenhouse gas emissions. (Storey, 1997) Agricultural policies have an impact on farming practices, such as land use, fertilizer use, irrigation and livestock activities, and as a result, have an affect on whether or not agriculture is a source or a sink for greenhouse gases.

For the most part, climate change objectives have not received attention in agricultural policy reform. Instead, emphasis has been placed on budgetary, trading issues and environmental issues. (Storey, 1997) Canada is still trying to determine how best to deal with the issue of climate change, and since the role of agriculture in greenhouse gas emission is just now being determined, it has received little direct attention. In spite of this however, some of Canada's recent policy changes have improved the conditions for adapting to climate change.

By removing policies that impact through negative incentives on land use changes, such as those the promote clearing more marginal land for crop production, the potential is to improve the role of the land as a sink as opposed to a source of greenhouse gases. Another example of this would be the removal of the Western Grain Transportation Act (Tyrczniewicz and Wilson, 1994). On the other hand, policies, such as the Permanent Cover Program of the Prairie Farm Rehabilitation Administration, are an example of policies implemented with the focus of improving the use and quality of the land.

Agricultural policies are not the only influencers on land-use; urban expansion and wildlife programs also have an impact of the role of the land as a sink or a source for greenhouse gases.

Urban expansion, zoning changes in particular, tends to lead to increased greenhouse gas emissions mainly due to the removal of potential sinks, such as vegetation. Wildlife programs policies tend to be focused on the expansion of wildlife habitat, and as a result are believed to improve the ability to sequester carbon. The North American Waterfowl Management Program, for example is geared to the expansion of existing wetlands as well as the creation of new wetlands. While the role of wetlands in carbon sequestration is not clear, wetlands have a major role to play in adapting to reduced water availability. As well, the uplands to the wetlands are considered very good sinks, as they tend to be made up of grasses and brush.

Why Adapt

While recognizing the need for efforts to reduce greenhouse gas emissions, agriculture needs to adapt to climate change for three main reasons. The first is that the climate is changing and production techniques need to change with it. Secondly, policy will change to assist Canada in meeting its goals for Kyoto. Finally, but of even more importance, farmers need to maintain a livelihood to support their families and to continue producing food and fibre. By adapting to climate change now, agriculture will be able to capitalize on the immediate benefits of the expected climate while minimizing the costs. It is also more effective and less expensive to adapt to climate change before being forced to use emergency adaptation techniques when the

best solutions are not necessarily available. Autonomous changes tend to have more options available than the policy-driven changes because policy changes are usually pressuring for a particular adaptation technique. While the changes in climate and policy will have an impact on agriculture, managing these changes effectively could result in reducing the negative impacts and increasing the positive impacts.

What Do We Need to Know

Adapting to changing climate and developing relevant climate policies requires information. The information needs to be timely, reliable and available to everyone who could benefit from it. The audience for this information varies from the policy-maker trying to determine what is happening on a global political scale to the farmer who is developing an operating plan for the farm. To effectively manage the climatic changes facing agriculture, techniques are required that examine the changing climatic variables and the political climate.

While the climate models are improving, they tend to offer information on a more macro scale than the typical user needs. As well they do not attempt to address other aspects of climate change, such as economic and social considerations. Models are required that incorporate social, economic and physical systems in addressing adaptation. The models should build on past experiences of adaptation, ranging from changes in policy, climate, technology and markets. It is with these models that policy results can be predicted before actually applying them. The recent effort of Agriculture and Agri-food Canada to incorporate climate change into the Canadian Regional Agricultural Model (CRAM) is a good example of this.

There has been a significant amount of research and studies directed at climate change and agriculture in Canada, and much of this literature has already been compiled in annotated bibliographic form (Canada Grains Council, 1998 and Wheaton, 1994). The problem is that this research is often piece meal, and is not being made available to those who need it. To successfully adapt to climate change, the current barriers to adaptation need to be addressed and removed, these barriers might range from out of date technology to policies indirectly affecting agriculture. The Canadian Adaptation and Rural Development (CARD) initiatives provide an opportunity to specifically consider climate change in the context of adaptation.

Farmers, processors, suppliers, policy-makers etc. will require information about how the climate is expected to change, what new technologies or practices are available, to determine their best possible options. Organizations around the world are starting to develop codes of good agricultural practices that help mitigate against adverse environmental impacts. (McKenzie-Hedger, 1997) The United Kingdom's Ministry of Agriculture, Fisheries and Food have developed Codes of Good Agricultural Practice for the Protection of Air, Water and Soil to help farmers avoid problems of water, air, soil pollution and degradation. While this was set up for environmental issues, the strategies can also be used effectively for climate change as well. The United States Department of Energy has developed "The Climate Change Action Plan" which is geared at reducing emissions through better input management (US DOE, 1994).

Farmers need to know the resilience of their crops and livestock to the changing climate as highlighted in the GCM predictions. In particular, crops and livestock that can be profitable at higher temperatures and lower precipitation need to be used more frequently. There is a need to know threshold levels of natural resources, such as the amount of water available, and the capacity of the land. In many cases, the landowner will have a good idea what the land is capable of producing, based on prior knowledge of how the land responded to previous climatic events. This knowledge could prove to be very valuable in adapting to climate change, and every effort should be made to tap into this resource.

What Do We Know

Adaptation has successfully taken place in agriculture in a number of ways over the course of its development in Canada. Farmers have successfully adapted their production and management practices to a variety of changes, such as technology, policy, and weather, but not all adaptation techniques are sustainable or successful. As indicated in the earlier section, there are regional differences in the impacts of climate change, and different adaptation techniques are required.

A vast amount of information is available on crop and livestock production from the research stations, universities and the private sector. While it has tended not to be focused on climate change, it is still useful for adaptation. Information is available about the necessary conditions to produce top quality product. Crop production techniques that reduce greenhouse emissions, energy consumption, or other inputs such as fertilizer, are considered no-regret techniques that are beneficial regardless of climate change. For example, zero or minimum tillage reduces the number of passes with tillage equipment, decreasing the amount of fuel consumed, as well as has the potential to reduce greenhouse gas emissions.

Livestock production knowledge is also very high. Information is available on waste management, feedstock, and housing, etc. The Climate Change Action Plan outlines a program that addresses ruminant livestock methane as one of its 44 actions. The program has six options for reducing emissions from cattle:

- Improved nutrition through feed processing and improved grazing management,
- Improved nutrition through strategic supplementation as part of pasture and range management,
- Production-enhancing agents to improve feed efficiency,
- Improved production through improved genetics characteristics,
- Improved production efficiency through improved reproduction, and
- Controlling disease.

Using this information, livestock operations can theoretically improve their production efficiencies as well as reduce emissions. This ties into the development of adaptation strategies to support the modification of existing policies building on the "no-regrets" activities and "win-win" options. (MacIver, 1998)

What Are the Gaps

The General Circulation Models appear to have some ability to predict the changing climate, but specific climate research is required that outlines impacts in each region of Canada's agriculture. Crop and livestock research is required based on the climate change models. Improving the climate predictions is beneficial, but farmers, as well as others, need to have long term weather predictions.¹

A better understanding of the linkages between agriculture, land-use, water-use, energy-use etc. is required. This is particularly important in the area of policy design, as changes in one sector might have significant impacts in other areas. Methods are required that can approximate some of this impacts.

Information exchanges between researchers and farmers are not frequent enough to benefit farmers and researchers. Canada needs to develop an action plan that outlines options for agriculture that takes advantage of no-regret activities as well as win-win situations.

The most significant gap for agriculture to adapt to climate change is the redirection of policy affecting agriculture. Canada needs to outline its climate change strategy as soon as possible to provide the agricultural community an idea of what it needs to adapt to.

¹ Climate is the average of multiple observations of the same time period, while weather is a one-time observation.

References

- Adger, Neil W., Pettenella, Davide, and Whitby, Martin (editors), *Climate-change Mitigation and European Land-use Policies*, CAB International, USA, 1997.
- Canada Grains Council, *Foundation Paper for Agriculture and Agri-food Climate Change Issues Table*, Draft, November 1998.
- MacIver, D.C., editor, *Adaptation to Climate Variability and Change – Workshop Summary*, Atmospheric Environment Services, May 1998.
- McKenzie-Hedger, Merylyn, *Agriculture and Forestry: Identification of Options for Net Greenhouse Gas Reduction*, Annex 1 Expert Group on the United Nations Framework Convention on Climate Change Working Paper no. 7, OECD, 1997
- Storey, Mark, "Policies and Measures for Common Action" *The Climate Implications of Agricultural Policy Reform*, OECD, July 1997
- Taylor, B., *Climate Change Scenarios for Canada: A User's Guide for Climate Change Impact Studies*. Pacific and Yukon Region, Environment Canada. Vancouver, British Columbia, 1996.
- Tyrchniewicz, Allen and Quentin Choitti, 'Agriculture and Climate Change: a Prairie Perspective' in Herrington, R., Johnson, B., and Hunter, F. (eds.) *Responding to Global Climate Change in the Prairies*, Environment Canada, 1997
- Tyrchniewicz, A. and A. Wilson, *Sustainable Development for the Great Plains: Policy Analysis*. Winnipeg: International Institute for Sustainable Development, 1994.
- US DOE (Department of Energy), *The Climate Change Action Plan: Technical Supplement*, Office of Policy, Planning and Program Evaluation, Washington DC., 1994.
- Wheaton, E.E. (1994) *Impacts of a Variable and Changing Climate on the Canadian Prairie Provinces: A Preliminary Integration and Annotated Bibliography*. SRC Publication No. E-2900-7-E-93. Saskatchewan Research Council, Saskatoon.